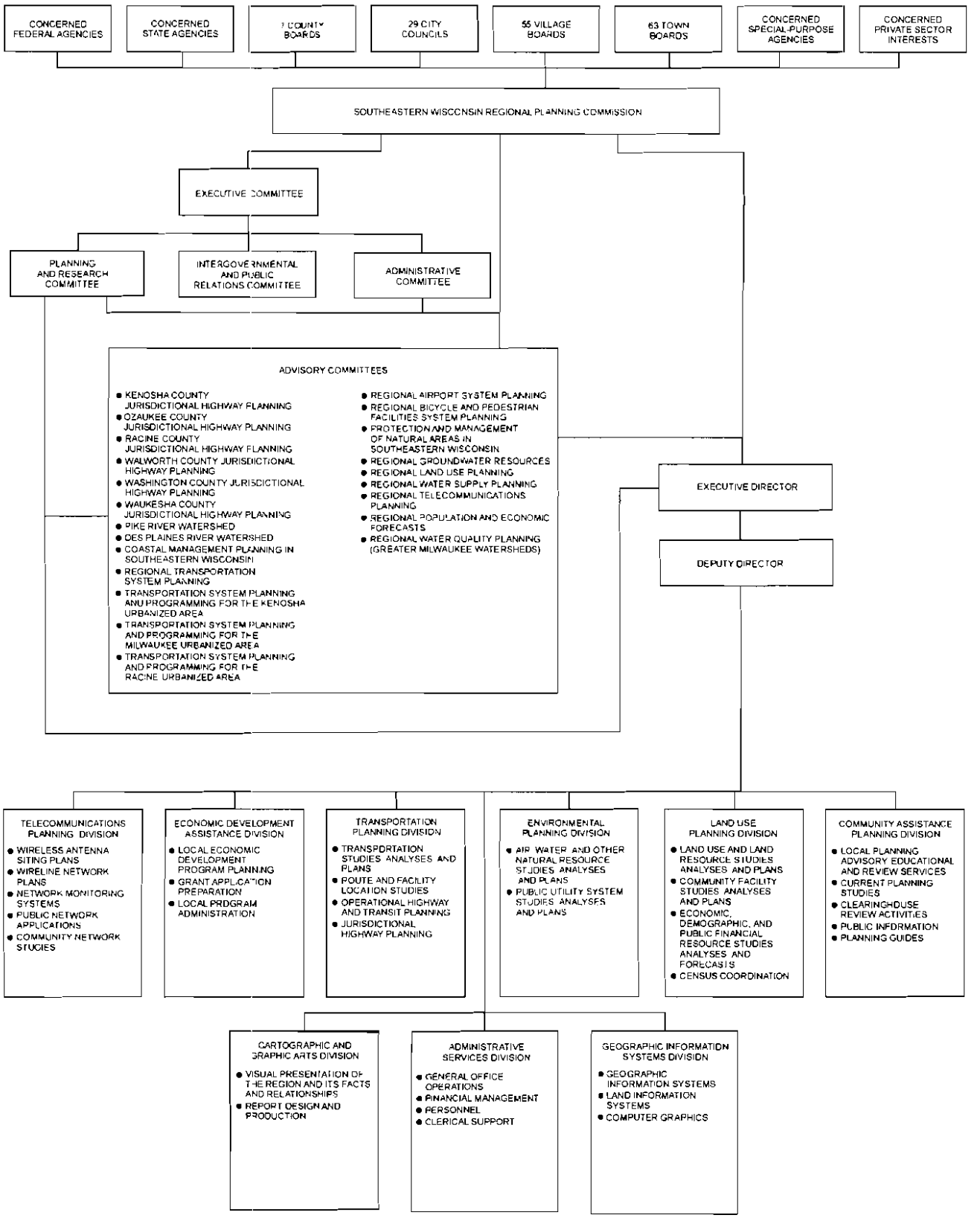
Figure 1

SEWRPC ORGANIZATIONAL STRUCTURE: 2005



cooperation between the governmental agencies and private enterprises responsible for the development and maintenance of land uses in the Region and for the design, construction, operation, and maintenance of the supporting public and private facilities. All Commission work programs are intended to be carried out within the context of a continuing overall planning program which provides for periodic re-evaluation of the plans produced and for the extension of planning information and advice necessary to convert the plans into action programs at the local, regional, state, and federal levels.

THE REGION

The Southeastern Wisconsin Planning Region, as shown on Map 1, is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Exclusive of Lake Michigan, these seven counties have a total of 2,689 square miles, or about 5 percent of the total land and inland water area of Wisconsin, and a total resident population of about 1.97 million people. About 36 percent of the population of the State lives in these seven counties, which contain three of the fifteen metropolitan statistical areas which are wholly or partially located in Wisconsin. The seven counties provide about 1.19 million jobs, or about 36 percent of the total employment of the State. The Region contains real property valued at about $145.4 billion as measured in equalized valuation, or about 37 percent of all of the tangible wealth of the State, as measured by such valuation. The Region contains 154 local units of government, exclusive of school and other special-purpose districts, and encompasses all or parts of 11 major watersheds.

Geographically the Region is located in a relatively good position with regard to continued growth and development. It is bounded on the east by Lake Michigan, which provides an ample supply of fresh water for both domestic and industrial use, and is an integral part of a major international transportation network. It is bounded on the south by the rapidly expanding northeastern Illinois metropolitan region and on the west and north by the fertile agricultural lands and desirable recreational areas of the rest of the State of Wisconsin. Many of the most important industrial areas and heaviest population concentrations in the Midwest lie within 250 miles of the Region, and over 27.3 million people reside within this radius.

COMMISSION WORK PROGRAMS TO DATE

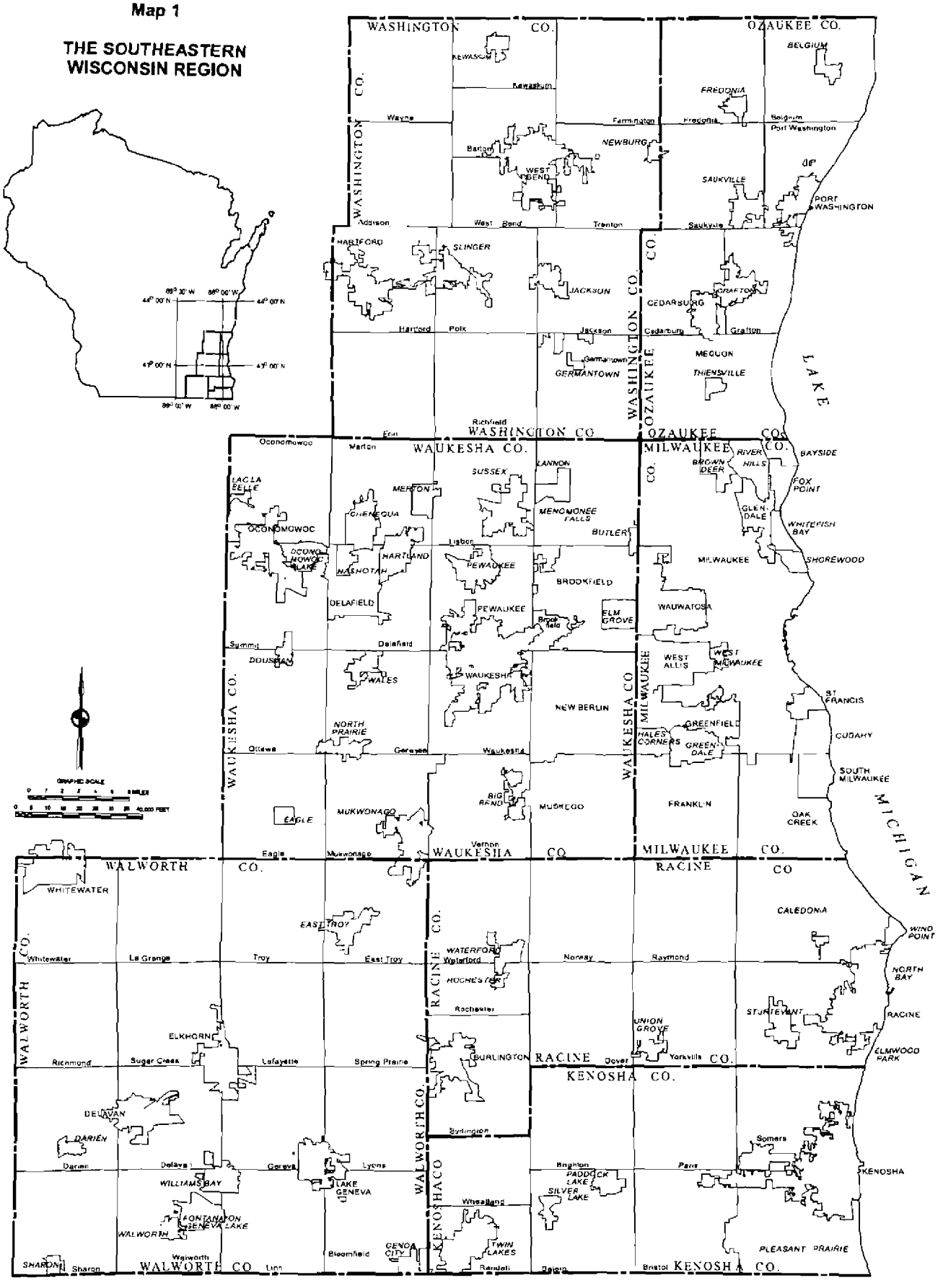
Since its creation in 1960, the Regional Planning Commission has diligently pursued its three basic functions of areawide inventory, plan design, and promotion of plan implementation through intergovernmental cooperation and coordination, although the relative emphasis placed upon these functions has changed somewhat over time. Initially, major emphasis in the Commission's work program was on the inventory function, with increasing attention being placed over the years on the plan design and on the intergovernmental coordination functions.

With respect to the inventory function, the Commission's planning program, as conducted since 1961, has resulted in the creation of a data bank containing in a readily usable form the basic planning and engineering information required for sound, areawide planning. The data assembled in the regional data bank include, among others, definitive data on streamflows; floodlands; surface and groundwater quality; woodlands, wetlands, and wildlife habitat; sites having scenic, scientific, cultural, and recreational value; soils; existing and proposed land uses; travel habits and patterns; transportation system capacity and utilization; existing and proposed utility service areas; and the demographic and economic base and structure of the Region. The data base also includes an extensive topographic and cadastral base mapping and horizontal and vertical survey control file. In wireless networks, the inventories include a comprehensive layout of antenna sites in the Region along with the areal coverage of these sites for the various wireless frequency bands and radio technologies.

Some of the data in the regional planning data bank have been assembled through the collation of data collected by other agencies. Data so assembled include data on highway and transit facility capacity, use, and service levels; transportation terminal facility capacity; automobile and truck availability; and population and economic activity levels. Much of the data in the regional data bank, however, have been assembled through original inventory efforts conducted by the Commission itself. Such inventory efforts have ranged from aerial photography, large-scale topographic and cadastral base mapping, and control survey programs; through extensive land use, woodland, wetland, wildlife habitat, potential park site, and public utility system inventories; to massive

Map 1

THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

travel inventory, detailed operational soil survey, and streamflow gaging and water quality monitoring efforts. Wireless inventory data sources used by the Commission include federal databases such as the Federal Communications Commission and Federal Aviation Administration; permit records of local units of govemment; and data from wireless service providers.

The regional planning data bank is supported by an extensive data conversion, filing, and retrieval capability which permits the basic data to be readily manipulated and tabulated by various geographic areas, ranging in size from the Region as a whole down through natural watersheds, counties, and minor civil divisions to planning analysis areas, census enumeration districts and tracts, traffic analysis zones, U.S. Public Land Survey sections and quarter-sections, and, for certain data, urban blocks and block faces. Of increasing importance in the regional planning data bank is the Commission's automated geographic information systems capability. A key regional map file consists of land use data which have been digitized, allowing for automated map reproduction and related data analysis functions. The Commission's planning data bank provides valuable points of departure for all Commission work efforts and is, moreover, available for use by the constituent agencies and units of government and the private sector.

With respect to the plan design function, the Commission has placed great emphasis upon the development of a comprehensive plan for the physical development of the Region in the belief that such a plan is essential if land use development is to be properly coordinated with development of supporting transportation, telecommunications, utility, and community facility systems; if the development of each of these individual functional systems is to be coordinated with the development of each of the others; and if serious and costly developmental and environmental problems are to be avoided and a safer, more healthful and attractive, as well as more efficient regional settlement pattern is to be achieved. Under the Commission's approach, the preparation, adoption, and use of the comprehensive plan are considered to be the primary objective of the planning process; and all planning and plan implementation efforts are related to the comprehensive plan.

Telecommunication networks have become a vital resource in the physical development of metropolitan regions. Business firms, local units of government, educational facilities, and individual households all depend on communications in the conduct of their daily lives and high speed—broadband—communications for data and video as well as voice communications is becoming an integral part of a modern society.

The comprehensive plan not only provides an official framework for coordinating and guiding growth and development within a multi-jurisdictional urbanizing region, but also provides a good conceptual basis for the application of systems engineering skills to the growing problems of such a region. The comprehensive regional plan also provides the essential framework for more detailed physical development planning at the county, community, and neighborhood levels.

As previously noted, because the scope and complexity of areawide development problems prohibit the preparation of an entire comprehensive plan at one time, the Commission has determined to proceed with the preparation of individual plan elements which together comprise the required comprehensive plan. By the end of 2003, the adopted regional plan consisted of 29 individual plan elements. Four of these elements are land use related: the regional land use plan, the regional housing plan, the regional library facilities and services plan, and the regional park and open space plan. Twelve of the plan elements relate to transportation. These consist of the regional transportation plan including highway and transit elements, the regional airport system plan, the transportation systems management plan, the elderly and handicapped transportation plan, the regional bicycle and pedestrian facilities plan, and detailed transit development plans for the Kenosha, Racine Waukesha, and West Bend urbanized areas and for Ozaukee, Washington, and Waukesha Counties. Eleven of the adopted plan elements fall within the broad functional area of environmental planning. These consist of the regional water quality management plan, the regional wastewater sludge management plan, the regional air quality attainment and maintenance plan, and comprehensive watershed development plans for the Des Plaines, Fox, Milwaukee, Menomonee, Kinnickinnic, Pike River, Root River, and Oak Creek watersheds. The final two

plan elements consist of comprehensive community development plans for the Kenosha and Racine urbanized areas.

The telecommunications planning program is new to the Commission with the initial planning studies beginning in 2004. The program initiation was in recognition of the vital role of telecommunications in the regional economy. In form, it most closely resembles transportation planning, with both relating to infrastructure networks. It differs, however, in the rapid pace of technological change and the role of private carriers in plan implementation.

The Commission also carries on an active community assistance planning program, in which functional guidance and advice on planning problems are provided to local units of government and regional planning studies are interpreted locally so that the findings and recommendations of these studies may be incorporated into local development plans and plan implementation programs. Six local planning guides have been prepared under this program to provide information helpful in the preparation of local plans and plan implementation ordinances. The subjects of these guides are land subdivision control, official mapping, zoning, organization of local planning agencies, floodland and shoreland development, and the use of soils data in development planning and control. Telecommunications planning services will also be extended to local units of government as part of the Commission's community assistance program. Beyond the questions related to antenna siting, some communities may require assistance in assessing telecommunications service levels and needs. Other communities have expressed interest in the Commission providing comprehensive telecommunications plans for expanding broadband telecommunication services in their areas.

TELECOMMUNICATIONS—DEFINITION AND IMPORTANCE

Telecommunication networks provide the infrastructure for information interchange in all advanced societies. Such networks are vital for the efficient production and distribution of goods and services in a modern economy. Telecommunication exchanges also serve to help weave the social and political fabric of modern day life. Recent and continuing advances in communications technology have allowed for information transfer at rates considered infeasible even a decade ago. Although originally developed for voice communication only, telecommunication networks now transmit data, video, and multimedia forms of information.

Varying rates of deployment of new communications technologies in different areas of the United States and in the rest of the world have produced one aspect of the so-called "digital divide,"[1] placing areas with outmoded telecommunication technologies at a competitive disadvantage in national and global commerce. Such disadvantaged areas are also prevented from introducing communications-based advances in fields such as telemedicine, public safety, education, environmental monitoring, and transportation that have major impacts on the quality of life. For all of the above reasons, telecommunications planning should be an important concern of elected and appointed public officials in a metropolitan region such as Southeastern Wisconsin.

One mode of telecommunications, terrestrial wireless communications, is advancing more rapidly than other modes such as traditional wireline and satellite wireless communications. Although the first commercial cellular wireless network did not become operable until 1983, wireless telephony is rapidly becoming the predominant form of local and long distance voice communication in the United States and elsewhere. Some countries in Europe and Asia, have higher rates of wireless telephone usage than does the United States. With the advent of the third generation (3G) of wireless communication technology, wireless is expected to become important in data and video as well as voice transmission. Beyond 3G networks, emphasis in this regional telecommunications plan is on fourth generation networks (4G) that will allow Southeastern Wisconsin to compete in a global economy. These 4G networks support data rates exceeding 20 megabits and are characterized as "big broadband" as compared to the "little broadband" of current telephone and hybrid

[1] *The term "digital divide" is commonly used to refer to the differences between households, businesses and other organizations that, for whatever reasons, have access to personal computers and the Internet and those that do not. It can also be used to distinguish between areas that are underserved in that the areas do not have high speed data service available. Such underserved—or disadvantaged—areas may exist in urban, as well as rural areas.*

cable networks which generally have throughput under six megabits per second. The comprehensive telecommunications plan alternatives will feature varying proportions of wireless and fiber wireline networks in access and backhaul networks depending on population density and other socio-economic variables.

ADVISORY COMMITTEE

The long-established practice of the Commission has been to conduct major regional planning programs with the assistance of appropriately structured advisory committees. The membership of such committees was to be drawn, as appropriate, to include knowledgeable and concerned representatives of the constituent counties and municipalities; of concerned State and Federal agencies; of the academic community; and of concerned private businesses and industries. Accordingly, an Advisory Committee on Regional Telecommunications Planning was created by the Commission to guide the preparation of the recommended plans. The Committee consists of the following members:

Kurt W. Bauer, Chairman	Executive Director Emeritus, SEWRPC
William R. Drew, Vice-Chairman	SEWRPC Commissioner; and Executive Director, Milwaukee County Research Park
Roger Caron	President, Racine Area Manufacturers and Commerce
Bob Chernow	Chairman, Regional Telecommunications Commission
David L. DeAngelis	Village Manager, Village of Elm Grove
Michael Falaschi	President, Wisconsin Internet
Barry Gatz	Network Supervisor, CenturyTel
Michael E. Klasen	Director of Regulatory Affairs, SBC
J. Michael Long	Attorney at Law, Mum and Martin, SC
Jeff Lowney	Vice President/General Manager, Time Warner Telecom
Jeff Mantes	Commissioner of Public Works, City of Milwaukee
Jody McCann	Network Domain Manager, Wisconsin Department of Administration, BadgerNet
George E. Melcher	Director, Office of Planning and Development, Kenosha County
Paul E. Mueller	Administrator, Washington County Planning and Parks Department
Rob N. Richardson	Director, Racine County Information Systems
Steven L. Ritt	Attorney at Law, Michael Best & Friedrich
James W. Romlein	Managing Director, MVLabs, LLC
Bennett Schliesman	Director, Kenosha County Emergency Management/Homeland Security
Dale R. Shaver	Director, Waukesha County Department of Parks and Land Use
Michael Ulicki	Vice President and Chief Technology Officer, Norlight Telecommunications
Darryl Winston	Director of Data Services, City of Milwaukee Police Department
Gustav W. Wirth, Jr.	SEWRPC Commissioner

Special acknowledgement is due the following former members of the Committee: Kenneth Brown, RF Engineer, Nextel Communications, Inc.; Brahim Gaddour, Director of Network Operations, Time Warner Telecom of Wisconsin; and Paul R. Schumacher, former Program Manager, TriCounty Business Partnerships.

PROSPECTUS

On December 4, 2002 the Commission authorized the preparation of a Prospectus for a Regional Telecommunications Planning Program. During the following year the Commission staff, under the guidance of a predecessor Advisory Committee, prepared a prospectus for a regional telecommunications planning program. This prospectus described in some detail the need for, and the major work elements of such a planning program. In December 2003, the Commission approved the initiation of a Regional telecommunications planning program based on this prospectus. The prospectus envisions the regional telecommunication plan to be comprised of two elements: a wireless antenna siting and related infrastructure plan; and an overall telecommunications network plan. In addition, the preparation of a technical report presenting the findings of an inventory of the existing regional telecommunications system and system performance; and a memorandum report on public enterprise networks were envisioned.

NEED FOR REGIONAL TELECOMMUNICATIONS PLANNING

Based upon a careful examination of the historical background and of the current state of telecommunications facilities and services within the Region, the Advisory Committee that guided the preparation of the afore-referenced Prospectus concluded that seven factors contribute to the need for the conduct of a regional telecommunications planning program and the preparation of a regional telecommunications plan for Southeastern Wisconsin. These factors are:

1. The lack of comprehensive information on the state of telecommunications facilities and services within the Region readily available to county and municipal officials, businessmen and industrialists, and concerned citizens.

   In past years, comprehensive information on the Regional telecommunications infrastructure was available from the Public Service Commission of Wisconsin (PSC). The PSC no longer has any jurisdiction over the growth areas of the telecom infrastructure, i.e. the packet-switched wireline network and all wireless networks. Without such information, public planning of any kind is not possible.

   Quality of service information on telecommunication services within the Region is also lacking. Many users of data services are often unaware of the degraded nature of transmission rates provided in some parts of the Region. Remedies for the correction of service deficiencies often take extended time periods with increasing subscriber frustration. At the same time, information on levels of service is rarely publicized. A regional network monitoring system could assist significantly in identifying network deficiencies as well as publicizing service quality levels throughout the Region.

2. The increasing need for advanced telecommunication facilities and services to support the economic development of the Region.

   Currently, primary economic competitors of the Region include countries of East Asia—South Korea, Japan and increasingly China. Manufacturing jobs especially are moving from Southeastern Wisconsin to East Asia. East Asia is reported to be ahead of the United States and the Region in broadband telecommunications services—both in terms of transmission speeds and in lower costs of these services. A regional telecommunications plan would assist Southeastern Wisconsin in recovering and maintaining its competitive position in the global economy by identifying the telecommunications infrastructure required to prosper in the current economic environment.

3. The need to address the universal provision of adequate broadband telecommunication services within the Region.

   A long term public approach to planning for the universal provision of broadband services within the Region is needed. Such an approach requires the evaluation of alternative network configurations and technologies to ascertain what is in the best socioeconomic interests of the people of Southeastern Wisconsin.

4. The need to address differences in the provision of adequate telecommunication services in rural and other underserved areas of the Region.

   The governor in 2003 called for the provision of universal broadband communication services to all areas of Wisconsin as part of a needed economic development program. Creative network design innovations are required to make such universal coverage cost-effective in rural and disadvantaged areas in a more effective manner. Such innovations can be evaluated as part of a regional telecommunications planning process.

5. The need to develop special purpose public telecommunication networks within the Region for applications such as telemedicine, public safety, transportation, environmental monitoring, and education.

   Some of the greatest benefits of advanced telecommunications technology can result from the development of special public networks in areas such as emergency telemedicine, home

health care telemedicine, air and water pollution monitoring, transportation system management, and education.

Many of these public network applications are regional in scope and planning for such would be enhanced by a regional telecommunication planning program.

6. The need to assist local units of government in telecommunication network development.

   Wisconsin municipalities have authority to provide telecommunications services, and court decisions have upheld this authority. Over 25 municipalities have been certified by the Wisconsin Public Service Commission to provide competitive telecommunications services. The Village of Jackson, within the Southeastern Wisconsin Region, is creating a broadband telecommunication utility to provide telecommunication facilities and services within the Village. Municipalities choosing this route could significantly benefit from planning assistance at the regional level. All municipalities within the Region will, however, require planning assistance with respect to telecommunication issues, particularly as related to future wireless and broadband communications services. In this respect, it should be noted that Section 66.0295(2)(d) of the Wisconsin Statutes requires that local comprehensive plans specifically address telecommunications facilities as an integral part of the utilities and community facilities element of such plans.

7. The need to develop a well-conceived comprehensive broadband telecommunications systems plan for the Region.

   Technical advances in telecommunications particularly in low cost wireless broadband networks have emphasized the need for a comprehensive telecommunications system plan for the Region. Based on detailed investigations of alternative wireless and fiber based wireline technologies, the plan will recommend broadband communication alternatives for all parts of the Region from low density rural areas to urbanized villages and cities.

PLAN DESIGN YEAR

The wireless antenna siting and related infrastructure plan for the Southeastern Wisconsin Region, as set forth in SEWRPC Planning Report No. 51, has a plan design year 2015. This design year was selected to correspond with the year 2015 stage of a set of new land use and transportation system plans being prepared for the Region. These plans are to have a design year 2035 with appropriate ten year stages. The plan design year of 2015 was also selected to provide a long-range, as opposed to a short-range, basis for the planning effort. Because of the rapidly changing economic, technological, regulatory, and market conditions concerned, private sector telecommunications planning efforts tend to be relatively short range, a five year time horizon often being used. A longer time horizon—10 years—was selected for the antenna siting and related infrastructure planning effort in order to permit the planning to reflect probable new technologies, including fourth generation (4G) wireless technology, and new versions of the Internet. A plan design year of 2015 was selected for the regional telecommunications plan presented in this report in order to be consistent with the plan design year selected for the wireless antenna siting and related infrastructure plan set forth in SEWRPC Planning Report No. 51. The designation of a design year is not intended to preclude the earlier introduction of 4G technology, but only to specify the latest date by which such technology should be in use within the Region.

SCHEME OF PRESENTATION

The findings and recommendations of the regional comprehensive broadband telecommunications system planning program are documented in this report. Following the Introduction, Chapter II sets forth the principles and concepts underlying the comprehensive broadband telecommunications planning program and outlines the major steps in the planning process. Chapter III presents the objectives of the comprehensive planning program and the standards by which alternative plans will be judged. Chapter IV documents the demographic, economic land use and transportation system inventory findings—the background conditions for the comprehensive telecommunications plan. Chapter V documents the findings of the broadband telecommunications

infrastructure inventory required for the planning effort. Chapter VI describes a wide range of performance inventory findings for both wireline and wireless broadband networks. Throughput performance in both the download and upload directions is tabulated and illustrated at the national, state and local levels. Chapter VII presents applicable technologies and alternative system plans for broadband service. The alternative regional broadband telecommunications system plans considered are described and costed in preparation for comparative plan evaluation and recommended plan selection in the chapter that follows. Chapter VIII provides the findings of the comparative evaluation of the alternative plans and based upon that evaluation, sets forth a recommended plan. Chapter IX deals with plan implementation. Chapter X provides a summary of the findings and recommendations of the regional comprehensive broadband telecommunication planning effort.

Chapter II

BASIC PRINCIPLES AND CONCEPTS

INTRODUCTION

In the preparation of a the comprehensive telecommunications system plan, the Regional Planning Commission followed a systematic planning approach that combined traditional regional planning procedures with well established telecommunications system engineering procedures. This chapter describes the approach followed by the Commission in preparing the comprehensive telecommunications system plan. More specifically, this chapter details the major elements of the planning process and how the telecommunications system engineering was integrated into the regional planning process. Definitions are provided for the various technologies concerned, both wireless and wireline, together with the descriptive parameters that characterize the applications of these technologies.

BASIC PRINCIPLES UNDERLYING THE REGIONAL PLANNING PROCESS

The planning process applied in the regional telecommunications planning effort is based on four basic principles. These are:

1. Telecommunications planning must be regional in scope. The need for and demand in telecommunication services develops over the entire urban region without regard to corporate limit lines. Thus, telecommunications planning cannot be accomplished successfully within the confines of a single municipality or a single county if that municipality or county is a part of a larger urban complex. The regional telecommunications system, which is comprised of wireless and wireline facilities and attendant services, must form an interoperable system over the entire region, a system which can adequately serve the developing telecommunication needs of the developing region.

2. Telecommunications planning must be conducted concurrently with and cannot be separated from land use planning. The land use pattern determines the amount and spatial distribution of the need and demand for telecommunication services; and for wireless communications, local use development has a major impact on radio propagation patterns.

3. Telecommunications planning must be comprehensive, considering in an integrated manner access, distribution and core networks using various wireless and wireline technologies for multiple service applications and media.

4. Private sector companies are significant providers of telecommunications services within the Region. These private sector companies independently prepare plans for the development of their networks; independently develop their own levels of service; and independently provide competitive services. Meaningful public tele-

communication planning effort must recognize the existence of these private sector planning efforts; and pursue the public planning effort in close cooperation with the private providers, actively involving these providers in the public planning process.

PLANNING PROCESS

The planning process used consisted of the following sequential work elements:

1. Formulation of Objectives and Standards
   A set of telecommunications facility and service objectives and standards were formulated. These objectives and standards emphasize the provision of areawide, low-cost, fixed, nomadic (laptop computer) and mobile broadband telecommunications facilities and services. The objectives are supported by a set of standards that provide quantifiable measures of availability, response time, throughput, and accuracy, the parameters that define the performance of a communications system that will meet the agreed upon objectives.

2. Conduct of Facilities and Services Inventory
   A sound planning process must be based upon factual data about the existing state of the system being planned. Such data are provided by an inventory function that for the communications infrastructure planning process includes the collation and collection of definitive information on the location of existing telecommunications infrastructure and on the technical specifications of the facilities. The inventory data are then used as inputs to the telecommunications network infrastructure planning process providing information on both communication needs and the ability of existing networks to service these needs. A second dimension to the inventory relates to network performance.

   A network monitoring system has been established at the Commission offices that provides a means for measuring the quality of the existing network services. A central server computer located at the Commission offices scans remote site transceivers located at various changing locations throughout the Region. The data collected from these scans is used to compile data on the quality of service within the Region.

   Additional performance data for both wireline and wireless network were collected through specialty websites that routinely record broadband communications throughput performance (DSL, cable and wireless) at the national, state and regional levels. These data allowed for comparisons with the SEWRPC monitoring system and for continuing updates on regional broadband performance.

   In order to be comprehensive, the inventory, in addition to infrastructure providing commercial service, also includes facilities that provide public support services.

3. Analyses and Forecasts
   In the classic approach to systems planning, forecasts are made of those factors that affect the structure of the system plan concerned, but which lie outside of the scope of the system being planned. Thus, public infrastructure systems planning typically involves the preparation of forecasts of probable future system demand—expressed in terms of such parameters as person trips, per capita sewage contribution, or per capita water demand—derived from population, household, employment, and land use forecasts for the plan design year. The forecast period is determined by the physical and economic life of the facilities concerned—for most types of public works facilities this period approximates 20 years. Procedures for developing such forecasts are well established and widely used for transportation, sanitary sewerage, storm water drainage and flood control, and water supply system planning. In transportation system planning, for example, population, household, employment, and land use forecasts are used to estimate future travel demand by mode. This demand is then used in the simulation of the performance of the arterial street and highway and transit systems through mathematical modeling. This permits quantitative analyses of the performance of alternative system plans considered, and facilitates the selection and more detailed design of a recommended system plan.

This classic approach to systems planning was originally intended to be applied in the regional telecommunications planning effort. The formulation and calibration of the necessary mathematical simulation models, however, required detailed information about the configuration, capacity and utilization of the existing telecommunications facilities within the Region that would permit the correlation of such utilization with socioeconomic and land use data for use in forecasting probable future demand. The necessary information was available only from the existing service providers, which refused to provide the information to the Commission. Therefore, the classic approach to systems planning could not be applied in the regional telecommunications process.

Consequently, a different approach to the plan design process was taken. Telecommunication supply and demand are known to be greatly influenced by the rate of new technology adoption and user acceptance. User acceptance is typically measured by a "take rate" which may vary widely, perhaps from 2 to 50 percent, or by a ratio of 25 to 1. This uncertainty of demand for a new broadband telecommunication service creates a need for system designs that may be expected to be profitable at the lowest expected take rate, but which have the capacity to accommodate much higher take rates at the desired levels of service. Thus, in the absence of being able to base alternative plan designs on long term forecasts and performance simulation, alternative plans were designed so that "break even" operation would be possible at low take rates, but which possessed capacities able to serve much higher take rates at the desired level of service.

In the planning process, the ability to achieve break even operation at low take rates was assessed on the basis of analyses of the capital costs involved. The adequacies of the system capacity were assessed on the basis of analyses of the level at which subscriber arrival rates and message sizes would become unacceptable with respect to the level of throughput desired. The alternative plans were, moreover, designed to permit the ready expansion of the initially available capacity through simple changes in the software and hardware concerned, without changes in the basic structure of the system plan. Analyses of the network capacities were based on modified versions of traffic engineering formulas originated by the Danish mathematician, A. K. Erlang, and used for many years by the Bell System in determining the capacity of circuit-switched telephone systems. The probability distributions involved—Poisson and Erlang—and their supporting algorithms were converted from circuit-switched to packet-switched network form for application to the network system plans developed under the regional telecommunications plan program.

4. Plan Design

   Plan designs are primarily generated based on two communications technologies: broadband wireless and broadband fiber wireline. These technologies compete in both access and core networks. The challenge of broadband communications system design is to select and deploy the most cost effective technology in urban, suburban and rural areas. Low density rural areas will generally favor wireless access networks with their low infrastructure cost and geographic coverage. High density urban areas, depending on their socio-economic characteristics, may support fiber-to-the premises networks. Business organizations with their high volume data requirements are also strong candidates for ultra-high speed fiber communications. In plan design, studies of various land use categories will be made to establish the basis for selected wireless and wireline networks throughout the Region.

5. Plan Test and Evaluation

   A number of means exist for plan test and evaluation. The most commonly used is system simulation in which a dynamic model of the network is used to simulate the performance of the existing system—or of alternative planned systems—on a computer. Such simulation can take place at varying levels of detail from high level evaluations of system capacity based on statistical estimates of subscriber usage, to detailed investigations of network packet transmissions. Interest at the regional system planning level emphasizes models that view a

network as a service provider. The objective of a modeling effort is to determine the system coverage and capacity and the level of service possible at various traffic loadings.

6. Plan Selection And Implementation
   Following public informational meetings and hearings on alternative wireless network plans, one of the alternative plans, or some composite version of these plans, will be adopted to help guide the short and long-range development of the regional telecommunications infrastructure within Southeastern Wisconsin. In presenting the alternative plans for public informational meetings and hearings, strong emphasis will be placed on the performance standards characterizing each alternative plan and how these standards relate to the capital investment and operating costs implicit in implementing each plan. Since one of the alternative plans will always represent a no-plan projection of current trends, these performance standards data will play a critical role in plan selection and adoption.

INVOLVED TECHNOLOGIES

Although the above description of the planning process delineates the basic work elements of regional telecommunications planning, it does not define the various technologies and provider networks that will establish the scope of the planning program. This section describes these technologies and networks as well as the frequency bands involved in wireless network planning in Southeastern Wisconsin.

Mobile Wireless Networks

The major antenna site users—owners or renters—in Southeastern Wisconsin are the mobile cellular/ Personal Communication System (PCS) service providers such as Cingular, Sprint/Nextel and Verizon. Based on the Commission inventory data there were, in 2005, 1,010 antenna sites within the Region. These sites are a resource not only for their present applications in second generation (2G, 2.5G) networks, but also as a resource for co-location of 3G and 4G networks.

The emphasis for wireless 2G, 2.5G and 3G infrastructure planning will be on a regional set of antenna sites that will provide adequate coverage, capacity, and quality of service for the Region as such coverage, capacity and quality of service are defined by objectives and standards set forth in this report. Second generation networks are already in place. Planning issues will relate mostly to coverage and quality of service. Third generation networks are just coming on the scene in Southeastern Wisconsin. Primary planning decisions here relate to planned coverage of the various service providers and their selection of antenna sites.

Fourth generation (4G) wireless infrastructure planning will proceed with significantly different objectives and procedures. The primary objective of the 4G plan is to present an imaginative, big broadband (20-100 megabits/second) fixed and mobile wireless plan for the Region that provides universal, region-wide coverage at affordable costs to all citizens of the Region. Current mobile cellular networks operate in the 800-900 MHz frequency bands. PCS networks utilize the 1900 MHz band. Although 3G networks will continue to operate in these same bands, 4G systems will move to higher frequencies such as the 5.2-5.9 GHz range.

Fixed Wireless Networks

Fixed wireless networks in the Region are currently small in size as compared to their mobile cellular/PCS counterparts. They are, however, expected to expand rapidly in the next few years, particularly with the advent of WiMAX technology. Most fixed wireless systems are now managed by Internet Service Providers (ISPs). Because they operate in higher frequency ranges (2.4 GHz or 5.7 GHz), their radius of coverage is limited to about 3 miles from each base station. Since they serve subscribers at fixed locations, there is no need to provide wide coverage, but instead they locate in areas with higher population densities to enhance their revenue potential. Most fixed wireless operators deploy proprietary systems such as the Motorola Canopy System. They tend to serve local areas mostly within a single county. In the future, however, it is expected that larger scale fixed wireless networks will be deployed by larger service providers offering a region-wide broadband service alternative. The advent of WiMAX (IEEE 802.16) technology is expected to lead to a merger of fixed and mobile communications networks all based on Internet operation. Although wireless communications networks, fixed and mobile, are now generally confined to frequencies below 6 GHz, future systems, particularly mesh network systems,

are expected to employ higher frequencies up to and including the 60 GHz band because of the faster transmission rates possible at these frequencies. Although shorter in range coverage and subject to strong atmospheric alternation, these frequency bands will play a role in multi-hop mesh network and other configurations. In some deployments, even free space near infrared optical links can expand performance capabilities.

Wireline Networks

Wireline networks in the form of telephone company DSL services and cable company hybrid fiber coaxial cable services dominate current day broadband telecommunication both in the Region and in the Nation at large. In their current forms, these technologies are reaching the limits of their performance capabilities. Advances for fourth generation broadband performance will require conversions to one of two emerging landline-based broadband telecommunications technologies – fiber-to-the-node (FTTN) and fiber-to-the-premises (FTTP).

In the FTTN approach, optical fiber cables are extended out from a telephone central office to a remote geographic node that will service users in an approximate 3,000 foot radius area using the existing copper wire infrastructure. Such a fiber-connected node using advanced forms of DSL such as VDSL is able to increase throughput performance levels to fourth generation standards exceeding 20 megabits per second. Still more advanced versions of DSL are promising throughputs up to 100 megabits per second. Although FTTN represents a significant advance for telephone service providers, it is architecturally quite similar to the hybrid fiber-coaxial cable structure employed by cable operators where optical fiber is brought to a "headend" which is then converted to an electrical signal for transmission on a copper-based coaxial cable to individual users.

A wireline technology with greater throughput performance potential utilizes an optical fiber connection direct to the end user – FTTP. Since a single optical fiber has throughput potential in the terabits per second range, FTTP in its pure form uses a dedicated individual fiber to connect each user to the central office. Such an arrangement is called an active optical network (AON). The performance of an AON is limited only by the electro-optical equipment employed at the central office and user ends of the dedicated fiber. For practical purposes, the bandwidth is essentially infinite. AON networks, however, are costly both in initial capital equipment and continuing maintenance costs. A simpler, lower-cost, but also lower performing optical architecture employs a passive optical network (PON).

In a PON network, there are no active electronic elements between the central office and the user. Rather a single fiber from the central office is passively split into multiple fibers—usually 32—at a remote location fanning out to serve 32 end users. PON networks are less costly to install and maintain, but they are also less able to utilize the full bandwidth of an optical fiber. Current PON networks are designed for throughputs around 100 megabits per second far below the data rate potential of the fiber medium.

SUMMARY

Regional planning for regional communications infrastructure development combines traditional planning procedures with the methodology of communications systems engineering. A six-step process is followed: beginning with the formulation of objectives and standards, and a determination of the current state of the system in terms of both infrastructure and performance. These two initial steps are followed by the preparation of forecasts of probable future demand for services which establishes the requirements for network coverage and capacity. Alternative plans meeting these requirements are then prepared, tested, and evaluated. The plan test involves computer simulation modeling that permits the evaluation of each alternative plan in terms of ability to meet the objectives and standards. The best plan is then selected for adoption and implementation. Implementation takes place in the form of guidance to private service providers and regulatory agencies concerned; or directly through public sector applications. The regional telecommunications planning process encompasses both wireline and wireless networks that also include fixed and mobile wireless technologies in both their present second (2G) and third (3G) generations, and future fourth generation (4G) technology that merges all of these technologies into one Internet based infrastructure.

Chapter III

OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

Planning is a rational process for formulating and meeting objectives. Therefore, the formulation of objectives is an essential task which must be undertaken before a comprehensive plan can be prepared and evaluated. Objectives guide the preparation of plans and, when converted to specific measures of plan effectiveness, termed standards, provide the structure for evaluating how well the plan meets planning objectives. Because planning objectives provide this basis for plan preparation and evaluation, the formulation of objectives is a particularly important step in the planning process.

Accordingly, a set of recommended objectives with supporting principles and standards was formulated as a part of the telecommunications infrastructure planning effort. The associated standards perform an important function in plan design since they provide the basis for relating the objectives to alternative plan configurations.

It is important to note that the objectives, principles, and standards presented herein are intended to serve as a basis for determining desired alternative and recommended telecommunications infrastructure. The standards, particularly, must be applied with judgment in the more detailed public and private planning and engineering studies which will be needed during plan implementation. The objectives, principles, and standards formulated herein relate to all portions of the comprehensive regional telecommunications plan to be prepared by the Regional Planning Commission. The comprehensive plan will include both wireless and wireline elements relating to core as well as access networks. The objectives, principles, and standards presented herein will also apply to all segments of the comprehensive plan.

It is also important to note that the objectives, principles, and standards presented herein were formulated within the context of other objectives, principles, and standards previously adopted by the Regional Planning Commission. These other objectives, principles, and standards relate to socio-economic, land use, transportation, and sewerage system development within the Region and to environmental protection and enhancement. As such, the telecommunications system development objectives, principles, and standards are intended to support these other regional development objectives, principles, and standards.

DEFINITIONS

The terms "objective," "principle," "standard," "plan," "policy," and "program" are subject to a range of interpretations. To clarify their meanings, the Regional Planning Commission has defined these terms as they are used within the context of this planning process as follows:

1. Objective: A goal or end toward the attainment of which plans and policies are directed.

2. Principle: A fundamental, generally accepted tenet used to support objectives and prepare standards and plans.

3. Standard: A criterion used as a basis of comparison to determine the adequacy of plan proposals to attain objectives.

4. Plan: A design which seeks to achieve agreed-upon objectives.

5. Policy: A rule or course of action used to ensure plan implementation.

6. Program: A coordinated series of policies and actions to carry out a plan.

Although this chapter deals with only the first four of these terms, an understanding of their inter-relationship and the concepts they represent is essential to the following discussion of objectives, principles, and standards.

To be useful in planning, objectives must be logical and clearly stated. The consideration of objectives for plan design and evaluation is facilitated by complementing each objective with one or more quantifiable standards. These standards are, in turn, directly related to a planning principle which supports the objective. The objectives relate primarily to the provision of wireless broadband telecommunications services within the Region, and to the desired performance of the system, its availability, and the overall quality of service. Each objective, together with its supporting principle and standards, is given in the following section. The following objectives, principles and standard, or standards are intended to be used in the formulation and evaluation of alternate telecommunications infrastructure plans and in the preparation of a recommended plan that will provide 4G wireless telecommunication services within the Region.

In considering the objectives and supporting standards set forth in this Chapter, it should be recognized that those objectives and supporting standards are intended to be applied at the system planning level, and that the effect of individual facilities on each other, or on the system as a whole, requires the application of mathematical models to quantitatively test alternative systems, thereby permitting adjustment of the subsequent configuration of the system concerned to meet the existing and forecast demand. It should also be recognized that an overall analysis of each alternative system plan considered must be made on the basis of cost. Such an analysis may show that the attainment of one or more of the standards is beyond economic practicality, and that the standard or standards concerned cannot be achieved and must be either reduced or eliminated. It should also be recognized that it is unlikely that any one plan proposal will meet all of the standards fully; and the extent to which each standard is met, exceeded, or violated must serve as a measure of the ability of each alternative plan considered to achieve the specific objectives which the given standard or standards compliment. It should be further recognized that certain objectives and standards inherently may be in conflict, requiring resolution through compromise; and that meaningful alternative plan evaluation can only take place through comprehensive assessment of each alternative plan considered against all of the objectives and standards. The selected plan will thus represent a compromise with respect to meeting conflicting objectives supporting standards. Finally, it should be recognized that the standards must be judiciously applied to areas which are already partially or fully served in order to avoid any unreasonable extensive reconstruction programs. Given the important role of the private sector in providing telecommunications facilities and services within the Region, and given the concern of these providers about the continued freedom to operate independently in a competitive market, it is important to note that the following objectives, principles, and standards are not intended to have any regulatory implications, but are intended for use solely in plan preparation and evaluation.

OBJECTIVES, PRINCIPLES, AND STANDARDS

Objective No. I—Broadband Telecommunications Performance

A level of broadband telecommunications performance that is competitive in a global economy and supports cost effective enhancements of public sector services.

Principle

High quality telecommunication services are vital to the expeditious conduct of national and international business and industrial transactions, and to prompt responses to emergencies. To be competitive in a global economy, the Region requires advanced, low cost broadband telecommunications services, which can be provided by either wireline or wireless telecommunications technology. The services should have a level of availability and continuity which facilitate business and industrial transactions, but which also ensure prompt responses to emergencies.

Standards

- Broadband communications services should provide a transmission rate in the range of 20 to 200 megabits per second.[1]
- Broadband communication networks should be available 99.9 percent of the time.[2]
- Voice service should be provided at a minimum MOS Standard Value of 4.0.[3]

Objective No. 2—Universal Broadband Telecommunications Services
The provision of broadband telecommunication services to all geographic areas of the Region.

Principle
Residents and organizations of the Region, regardless of geographic location, should be offered an equal access to broadband telecommunications services in order to promote the social and economic welfare of the Region.

Standards

- Broadband communications network coverage should be provided in all geographic areas of the Region and should be available to all residences, businesses, industries, and organizations of the Region.

Objective No. 3—Redundancy
The provision of alternative transmission paths through the individual providers of telecommunication networks so as to minimize network congestion, reduce susceptibility to interference, and provide high immunity to catastrophic failure.

Principle
Robust and reliable networks are required in a communications dependent economy and society and in emergency situations.

Standard

- Redundancy is measured based on the average number of alternative transmission paths between users in a network. Desirably, the ratio of the average number of alternative transmission paths to the total number of links in the network should be at least 20 percent.[4]

Objective No. 4—Antenna Site Number Optimization
The number of wireless antenna site locations within the Region should be optimized.

Principle
Optimization of the number of antenna sites within a planning area is consistent with minimization of infrastructure investment costs, with the provision of redundancy in the service of each individual provider, and with promotion of environmental protection and the pursuit of a high aesthetic quality in the land and cityscape.

Standard

- The number of antenna sites should be the smallest number that provide universal coverage and quality of service within the Region.

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[1] *The generally accepted range for both IEEE 802.16a, d and 4G wireless networks is 20 to 100 megabits per second. The high end target value was raised to meet the needs of high definition television on demand.*

[2] *While wireline telephone service has a general availability standard of 99.999 percent (equivalent to a total of 3 minutes down time per year), wireless service availability has not yet reached this level. The standard of 99.9 percent (equivalent to a total of 8.6 hours of down time per year) is believed to represent an achievable goal by the plan target year 2015.*

[3] *Mean Opinion Score, (MOS) was originally defined based upon a subjective evaluation of voice quality by a group of listeners. It is now objectively defined as an ITU-T P.800 specification, and is determined from a standard formula based upon signal to noise ratio (SNR), line delays, and other factors. The value ranges from 1.0 to 5.0, corresponding to lowest and highest levels of voice quality satisfaction.*

[4] *This standard value was based on partial mesh paths in a full mesh topology where the number of links L=N(N-1))/2; and N=number of nodes in network.*

Objective No. 5—Serve Most Demanding Application

Telecommunications systems should be designed to serve the most demanding expected system application, thereby permitting all applications to be accommodated.

Principle

The planned telecommunication system should not preclude needed applications of the system.

Standard

- The planned network bandwidth should be the broadest possible with projected technologies within the planning period; approximately 200 megabits per second.

Objective No. 6—Network Infrastructure Cost Minimization

Achieve the provision of wireless telecommunication networks which are both economical and efficient, meeting all other objectives at the lowest cost possible.

Principle

Minimization of capital and operating costs conserves limited public and private capital resources. Any undue investment in telecommunication facilities and services must occur at the expense of other public and private investment; therefore, total telecommunication costs should be minimized for the desired level of service.

Standards

- The sum total of telecommunication system capital investment and operating costs should be minimized.
- Full use should be made of existing facilities and such facilities should be supplemented only with additional major facilities as necessary to serve the anticipated demand for the desired level of services.

Objective No. 7—Antenna Site Aesthetics and Safety

A high aesthetic quality and safe design in the telecommunication antennae and supporting structures and equipment with proper visual relation to land and cityscape.

Principle

Beauty and safety in the physical environment are conducive to the physical health and well-being of people; and as major features of the land and cityscape, telecommunication facilities have an important impact on the aesthetic quality of the total environment. In order to ensure public safety, careful attention must always be given to structural design principles and practices, including careful conformance to existing regulatory codes.

Standards

- Telecommunication facilities should be located to avoid the destruction of visually pleasing buildings, structures, and natural features, and to avoid interference with visitors to such features.
- Co-location on existing antenna sites is preferred over new antenna support structure deployment.
- Antenna locations on existing buildings, or other existing structures are preferred over new antenna tower construction.
- Antenna structures should be designed, constructed and maintained to insure a safe environment.
- Antenna support structure heights should be minimized consistent, however, with maximizing the potential for antenna co-location, and with providing a potential for height extension and capacity expansion.

Objective No. 8—Preference For Use In Public Safety Emergencies

A broadband telecommunications network that assures capacity for, and provides preference to police, fire, emergency medical, and homeland security agencies for use in times of public emergencies.

Principle

The potential for interagency communication by police, fire, emergency medical, and homeland security agencies in times of public emergencies—such as national disasters including flooding and